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(56) Documents Cited
GB 0337249 A WO 98/53202 A1 WO 92/01142 A1
JP 100210698 A US 5685701 A US 4699017 A

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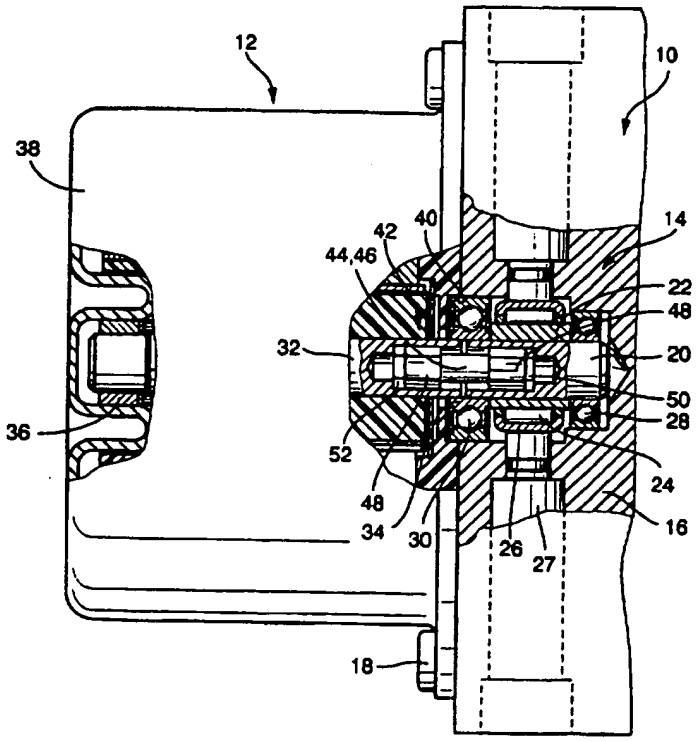
(54) Abstract Title
Coupling and common bearing between ends of a motor shaft and a pump shaft

(57) A pump unit 10, particularly for a vehicle braking installation, comprises a radial piston pump 14 having a pump shaft 20 driven by a shaft 32 of an electric motor 12, with the mutually facing ends of the motor shaft 32 and the pump shaft 20 being both directly mounted in a single ball bearing 30 and being rotatably connected by a coupling shaft 44 having two hexagonal profile end sections 48 which extend into complementary hexagonal internal profiles 50,52 in hollow end sections of the shafts 20,32. The coupling arrangement compensates for misalignment and axial displacement between the shafts 20,32.



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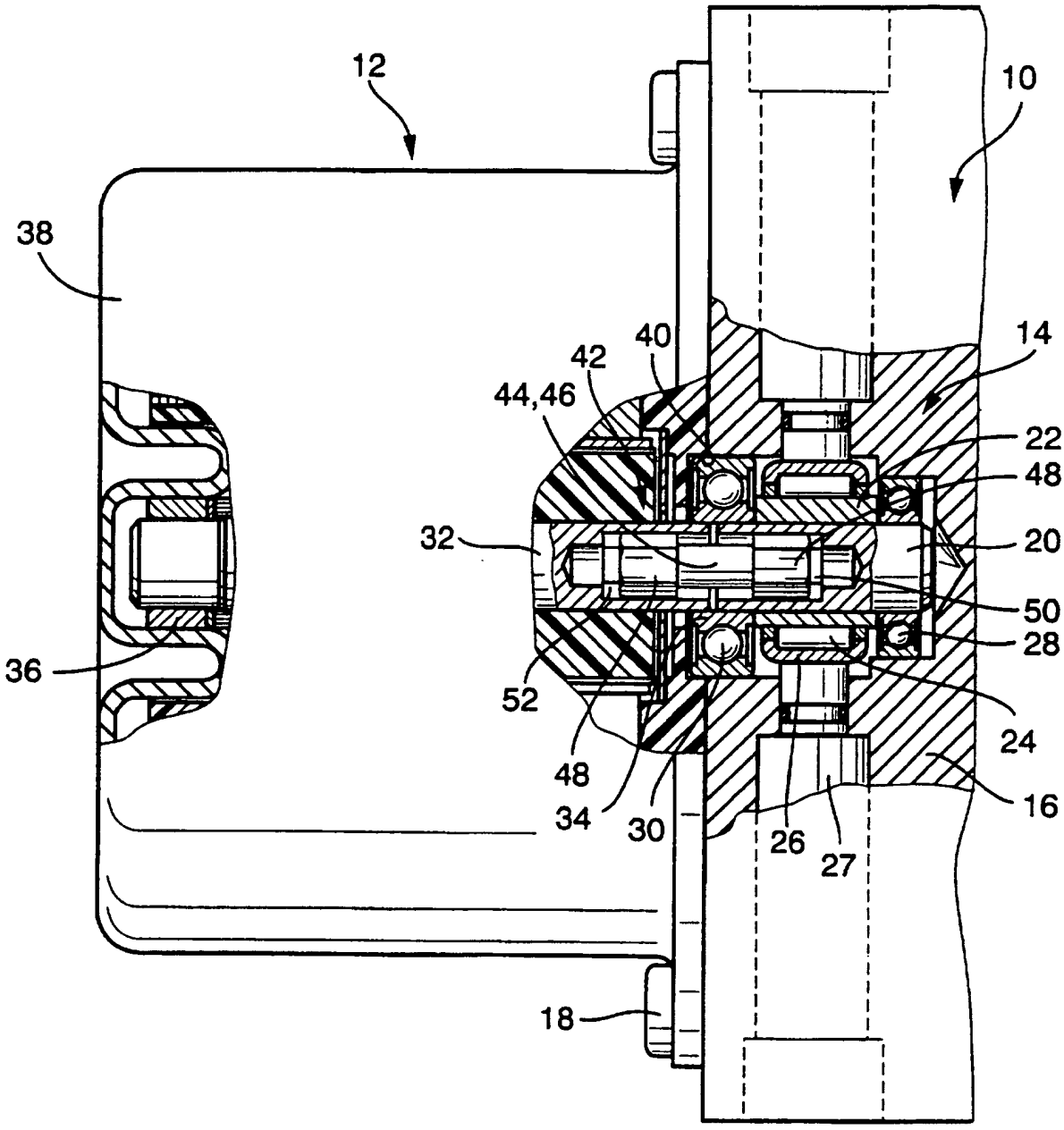
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Pump unit

The invention relates to a pump unit of the kind in the main claim, which is intended particularly for a slip-regulated vehicle braking installation.

These days, pump units of this type are no longer used merely for braking slip regulation (ABS), but increasingly for other functions too, such as drive slip regulation (ASR), travel dynamics regulation (FDR), distance regulation (ECD) or even for generating braking pressure in electrohydraulic (external-power) vehicle braking installations. These additional functions increase the running time of the pump unit to a multiple, a fact which raises the demands on its service life. The additional functions also entail the pump unit starting up without a driver actuating the brake. The noise which occurs, in a manner that surprises the driver, when the pump unit starts up and runs may irritate the driver. This fact, and also the demand that the vehicle's occupants be troubled as little as possible by noise, imposes growing requirements on the quietness of the pump unit. It is therefore important that rotating parts of the pump unit be mounted in a low-vibration manner, particularly if a pump belonging to the pump unit, such as a piston pump for example, effects delivery in a discontinuous manner and can thereby induce the rotating parts of the pump unit to vibrate. At the same time, the mounting arrangement should be free from mechanical stresses, that is to say should be in alignment.

A pump unit for a slip-regulated vehicle braking installation is known from WO 98/53202. The pump unit has an electric motor and a pump to which the said electric motor is fastened and which can be driven by the latter. The pump has a bearing which is disposed between the pump and the electric motor and in which a pump shaft is directly mounted in a rotatable manner. A motor shaft belonging to the electric

motor is separate from the pump shaft, and the two shafts are connected to one another in a torsion-proof manner. For torsion-proof connection purposes, the motor shaft exhibits a section which is provided with a multi-sided, polygonal or many-toothed profile and which is enclosed in a complementary internal profile in the pump shaft. That end section of the motor shaft which is enclosed in the pump shaft forms, together with the latter, a non-shiftable coupling which is torsion-proof as a result of form-locking. The motor shaft is rotatably mounted, in an indirect manner via the pump shaft in which it is enclosed, in the bearing disposed between the electric motor and the pump.

The known pump unit has the disadvantage that highly accurate external profiling of the motor shaft and highly accurate internal profiling of the pump shaft are necessary in order to mount the motor shaft, which is held only indirectly via the pump shaft in the bearing disposed between the electric motor and the pump, with sufficient rotational accuracy. The manufacture of the motor shaft and pump shaft is therefore complicated and expensive, and increased spoilage has to be taken into account. On top of that, the coupling must be free from play and the motor shaft must be enclosed in the pump shaft in a play-free manner in order to achieve sufficient rotational accuracy on the part of the motor shaft, which is mounted in the bearing only indirectly via the pump shaft. This has the disadvantage that errors of alignment in a motor-shaft bearing remote from the pump, in a pump-shaft bearing remote from the motor and in the bearing disposed between the electric motor and the pump, give rise to mechanical stressing of the motor shaft and pump shaft which induces mechanical vibrations during rotation and causes increased bearing wear. Although this problem can be countered by leaving out the bearing remote from the pump or the bearing remote from the motor, this nevertheless has the disadvantage that either the motor shaft is only mounted at one end and the rotating parts of the electric motor may begin to vibrate, or else that the pump shaft is only supported at one end.

Advantages of the invention

In the pump unit according to the invention having the features in claim 1, the motor shaft is rotatably mounted, in just the same way as the pump shaft, directly in the bearing disposed between the electric motor and the pump, and not indirectly via the pump shaft. As a result of this, a high degree of rotational accuracy on the part of both the motor shaft and also of the pump shaft is achieved, so that the coupling connecting the two shafts to one another in a torsion-proof manner can be designed with low requirements as regards accuracy. The coupling can be designed with play. This simplifies assembly and also lowers the cost of manufacturing the motor shaft and pump shaft and reduces the spoilage.

The coupling in the pump unit according to the invention has a coupling shaft which is in engagement, at two points which are at a distance from one another axially, preferably at its end sections, with the motor shaft and pump shaft in a torsion-proof manner by form-locking, but at the same time exhibits angular and axial play in relation to the motor shaft and pump shaft. The torsion-proof form-locking combined with angular and axial play can be produced, for example, with the aid of a multi-sided, polygonal or many-toothed profile, a tongue-and-groove connection or a transverse pin. The coupling shaft forms a type of cardan shaft which is coupled to the motor shaft and pump shaft in a torsion-proof manner by form-locking and which can be pivoted sideways in relation to the motor shaft and pump shaft about an angle and is displaceable in the axial direction. The coupling shaft compensates for errors of alignment of the motor shaft and pump shaft, that is to say both angular errors and also parallel misalignment and axial displacements, the latter, for example, as a consequence of thermal expansions. Under these circumstances, particularly high requirements as regards accuracy are not imposed on the manufacture of the coupling in the pump unit according to the invention, since inaccuracies in the coupling do not

affect the concentric running of the motor shaft or pump shaft, or the behaviour of the rotating parts of the electric motor as regards vibration. The motor shaft, coupling shaft and pump shaft can therefore be manufactured inexpensively and spoilage as a consequence of manufacturing inaccuracies is low. On top of that, in addition to being mounted in the bearing disposed between the electric motor and the pump, the motor shaft can be mounted at its end which is remote from the pump, and the pump shaft at its end which is remote from the motor, without distortion of the motor shaft or pump shaft occurring because of misalignment of the bearings, of which there are three in all, of the pump unit as a consequence of tolerances. According to the invention, it is thereby possible to mount the pump shaft at both its ends, and thereby support it in a stable manner against radial forces in the pump, and to likewise mount the motor shaft at both its ends in order to prevent vibration of the rotating parts of the electric motor. The mounting of the motor shaft and pump shaft in a stress-free and low-vibration manner lessens running noise on the part of the pump unit and also bearing wear.

The subclaims have as their subject advantageous refinements and further developments of the invention indicated in claim 1.

A low-vibration mounting arrangement, that is to say one which avoids, limits or damps vibrations, is particularly advantageous when the pump, such as, for example, a piston pump (claim 3), of the pump unit effects delivery in a discontinuous manner (claim 2), and may thereby induce the rotating parts of the electric motor to vibrate.

Drawing

The invention will be explained in greater detail below with the aid of an exemplified embodiment which is represented in the drawing. The single figure shows a pump

unit according to the invention, in axial section.

Description of the exemplified embodiment

The pump unit according to the invention, which is represented in the drawing and is designated, as a whole, by 10, has an electric motor 12 and a pump 14 which is constructed as a radial piston pump. The said radial piston pump is accommodated in a hydraulic block 16 which forms a pump housing. The pump unit 10 is intended for the delivery of brake fluid in a hydraulic vehicle braking installation, of which nothing further is represented, for example for braking slip, drive slip, travel dynamics and distance regulation (ABS, ASR, FDR, ECD). The electric motor 12 is screwed to the hydraulic block 16 by means of screws 18.

The radial piston pump 14 has a pump shaft 20 onto which an eccentric ring 22 is pressed in a torsion-proof manner. The said eccentric ring 22 has a bore which is formed eccentrically in relation to its outer periphery and with the aid of which it is pressed onto the pump shaft 20. Slipped onto the eccentric ring 22 is a needle bearing 24, against the running sleeve 26 of which two pistons 27 belonging to the radial piston pump 14 rest with their end faces. As a result of the pump shaft 20 being driven in a rotating manner, the pistons are driven by the eccentric ring 22, in a manner known *per se*, to perform a reciprocating stroke movement for delivering brake fluid. The pump shaft 20 is rotatably mounted, by means of two ball bearings 28, 30 on either side of the eccentric ring 22, in the hydraulic block 16 forming the pump housing. One of the two bearings 30 is disposed between the radial piston pump 14 and the electric motor 12.

Under these circumstances, the bearing 30 disposed between the electric motor 12 and the radial piston pump 14 may be designed as a fixed bearing, and a bearing 28 remote

from the electric motor 12 as a loose bearing, or conversely the bearing 30 disposed between the electric motor 12 and the radial piston pump 14 may be designed as a loose bearing, and the bearing 28 remote from the electric motor 12 as a fixed bearing. Fixed bearing means that the bearing is pressed into a bearing receptacle in the pump housing 16 and the pump shaft 20 is pressed into the bearing. The fixed bearing fixes the pump shaft 20 in position axially. Loose bearing means that the bearing is pressed into a bearing receptacle in the pump housing 16 and the pump shaft 20 is a sliding fit in the said bearing. The loose bearing permits axial mobility of the pump shaft 20 for the purpose of compensating for axial tolerance and thermal expansions.

The electric motor 12 is a conventional electric motor of a structural type which is known *per se*, such as is known in a multitude of designs to the person skilled in the art. It is therefore superfluous to go into the make-up and functioning of the electric motor 12 in any greater detail in the context of the present invention.

The electric motor 12 has a motor shaft 32 which is separate from the pump shaft 20 and of which one end is mounted, in just the same way as the pump shaft 20, in the ball bearing 30 disposed between the electric motor 12 and the radial piston pump 14. Both the motor shaft 32 and the pump shaft 20 protrude a short distance into an inner race 34 of the ball bearing 30 disposed between the electric motor 12 and the radial piston pump 14, and therefore each of the two shafts 20, 32 is received and rotatably mounted directly in the ball bearing 30. The motor shaft 32 is in alignment with the pump shaft 20. By mounting the two mutually facing ends of the motor shaft 32 and pump shaft 20 jointly in one ball bearing 30, a bearing is dispensed with. Misalignment of the shafts is prevented by the joint mounting thereof in one ball bearing 30.

An end of the motor shaft 32 which is remote from the pump is rotatably mounted in

a motor bearing 36 which is inserted in a motor housing 38. The motor bearing 36 is a plain bearing which is designed as a sintered metal bearing, the pores of which are filled with an ageing-resistant lubricating oil for permanent lubrication.

The ball bearing 30 disposed between the electric motor 12 and the radial piston pump 14 is inserted in the hydraulic block 16 forming the pump housing, in such a way that it protrudes a short distance. The electric motor 12 has a cylindrical counter-bore 40 which is an accurate fit in relation to the ball bearing 30 and by means of which the said motor is slipped onto that part of the ball bearing 30 which protrudes from the hydraulic block 16, and thereby oriented on the latter so as to align with the radial piston pump 14.

For connecting the pump shaft 20 to the motor shaft 32 in a torsion-proof manner, the pump unit 10 according to the invention has a non-shiftable coupling 42 which comprises a coupling shaft 44. The said coupling shaft 44 is manufactured from a hexagonal bar which is turned to a smaller diameter in a central section 46. The two end sections 48 of the coupling shaft 44 have a hexagonal profile which may be of crowned construction.

The mutually facing end sections of the pump shaft 20 and motor shaft 32 are constructed as hollow shaft sections and have a hexagonal internal profile 50, 52 which is complementary to the hexagonal profiles 48 on the coupling shaft 44, there being play between the hexagonal profiles 48 on the coupling shaft 44 and the internal hexagonal profiles 50, 52 in the pump shaft 20 and motor shaft 32. Because of the hexagonal profiling, the coupling shaft 44 transmits a rotational movement of the motor shaft 32 to the pump shaft 20 in a form-locking manner. Because of the play between the coupling shaft 44 and the pump shaft 20 and also the motor shaft 32, the coupling shaft 44 can be averted sideways about an angle in a manner similar to a

cardan shaft, and can thereby compensate for errors of alignment, that is to say both parallel misalignment and also angular errors, between the pump shaft 20 and motor shaft 32. The coupling shaft 44 is enclosed in an axially displaceable manner in the hexagonal internal profiles 50, 52 in the motor shaft 32 and pump shaft 20, as a result of which the coupling 42 also compensates for axial displacements between the pump shaft 20 and motor shaft 32 in consequence, for example, of temperature expansions. The central section 46, which is smaller in diameter, does not hinder avertence of the coupling shaft 44 in the motor shaft 32 or in the pump shaft 20.

For the purpose of constructing the coupling 42 as a flexible coupling, the coupling shaft 44 may be constructed in a torsionally flexible manner by selecting a small transverse gauge or diameter. The coupling shaft 44 can also be constructed in a torsionally flexible manner by manufacturing it, for example, from plastic or as a steel/plastic composite part with a plastic-coated steel core or with a central section 46 made of plastic. It is also possible to coat the hexagonal profiles 48 on the coupling shaft 44 with plastic or to draw on a plastic hose which maintains the connection, which is torsion-proof as a result of form-locking, between the pump shaft 20 and motor shaft 32 and acts as a damping element. As a result of constructing the coupling 42 flexibly in this way, fluctuations in torque when the radial piston pump 14 is driven, which are the consequence of the discontinuous manner of delivery by the said pump, are damped and there is a reduction in the inducement of the motor shaft 32, and also of parts of the electric motor 12 (armature winding, commutator) which co-rotate with the said shaft, to vibrate.

Patent claims

1. Pump unit for a slip-regulated vehicle braking installation, the said unit having an electric motor which has a motor shaft, and having a pump which can be driven by means of the electric motor and has a pump shaft which is connected to the motor shaft in a torsion-proof manner via a non-shiftable coupling, and having a bearing which is disposed between the electric motor and the pump and with the aid of which the pump shaft is directly mounted in a rotatable manner, **characterised in that** the motor shaft (32) is also directly mounted in a rotatable manner with the aid of the bearing (30) disposed between the electric motor (12) and the pump (14), and that the coupling (42) has a coupling shaft (44) which is in engagement, in a torsion-proof manner by form-locking and with angular and axial play, with the motor shaft (32) and pump shaft (20) at two points (48) which are at a distance from one another axially.

2. Pump unit according to claim 1, **characterised in that** the pump (14) is a pump (14) which effects delivery in a discontinuous manner.

3. Pump unit according to claim 2, **characterised in that** the pump (14) is a piston pump (14).

4. Pump unit according to claim 1, **characterised in that** the coupling shaft (44) has a multi-sided profile (48) which is in engagement with a complementary profile (50, 52) in the motor shaft (32) and/or the pump shaft (20).

5. Pump unit according to claim 1, **characterised in that** the coupling shaft (44) has a reduced cross-section (46) axially outside the points (48) of engagement with the pump shaft (20) and with the motor shaft (32).

6. Pump unit according to claim 1, **characterised in that** the coupling (42) is constructed as a flexible coupling (42).

7. Pump unit according to claim 1, **characterised in that** the bearing (30) disposed between the electric motor (12) and the pump (14) is enclosed both in a bearing receptacle (40) in the electric motor (12) and also in a bearing receptacle in the pump housing (16) of the pump (14).

8. Pump unit according to claim 1, **characterised in that** the bearing (30) disposed between the electric motor (12) and the pump (14) is pressed into the bearing receptacle in the pump housing (16) and the pump shaft (20) is pressed into the bearing (30) (fixed bearing) disposed between the electric motor (12) and the pump (14), and that a bearing (28) remote from the electric motor (12) is pressed into a bearing receptacle in the pump housing (16) and the pump shaft (20) is a sliding fit in the bearing (28) (loose bearing) remote from the electric motor (12).

9. Pump unit according to claim 1, **characterised in that** the bearing (30) disposed between the electric motor (12) and the pump (14) is pressed into the bearing receptacle in the pump housing (16) and the pump shaft (20) is a sliding fit in the bearing (30) (loose bearing) disposed between the electric motor (12) and the pump (14), and that a bearing (28) remote from the electric motor (12) is pressed into a bearing receptacle in the pump housing (16) and the pump shaft (20) is pressed into the bearing (28) (fixed bearing) remote from the electric motor (12).

10. A pump unit for a slip-regulated vehicle braking system substantially as herein described with reference to the accompanying drawing.

Application No: GB 0013381.9 **Examiner:** Robert Crowshaw
Claims searched: 1 to 9 **Date of search:** 20 August 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): F1W (WCT); F2U; H2A (ARJ1, ARX1, ARX3)

Int Cl (Ed.7): F04B 1/04, 9/04, 17/03, 53/00; F16D 1/02, 3/06, 3/50; H02K 5/167, 5/173, 7/08, 7/14

Other: Online databases: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 0337249	(ELECTRIC SCALING HAMMERS) Figure 1.	
Y	WO 98/53202 A1	(BOSCH) Figure 1.	1-3
A	WO 92/01142 A1	(DECO-GRAND) Page 12 lines 2-3.	
A	US 5685701	(METAULLICS SYSTEMS) Figure 3.	
Y	US 4699017	(CIM) Whole document particularly relevant for a shaft coupling and bearing.	1-4
Y	JP 100210698 A	(SAWAFUJI) 1998-08-07. See WPI Abstract Accession No. 1998-488119 [42].	1, 4

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.